

**Rec'd PCT/PTO 19 MAR 2002**

METHOD FOR SETTING UP A DIALYSIS TREATMENT IN A DIALYSIS  
MACHINE.

The present invention relates to a method of setting up a dialysis treatment in a dialysis machine.

In general, dialysis machines are preset for carrying out dialysis treatments that are personalized for patients affected by renal insufficiency. In other words, the dialysis machines have control devices that make it possible to set up a dialysis treatment that is specific to each patient on the basis of the medical instructions. As a rule, a prescription for a patient affected by renal insufficiency and undergoing dialysis treatment comprises instructions relating to the weight loss that the patient should experience and to the amount of salts that the patient should receive in the form of ions during the dialysis treatment. Other data characterizing the dialysis treatment, such as the maximum weight loss in unit time tolerated by the patient and the duration of the dialysis treatment, can be obtained from the general conditions of health and from the patient's physical characteristics. The weight loss during a dialysis treatment is due to expulsion of a proportion of the blood fluid.

For this purpose, a dialysis machine of known type comprises an extracorporeal blood circuit connected, in use, to the patient's circulatory system, a dialysate circuit, and a filter through which the blood circuit conveys the blood fluid and the dialysate circuit conveys the dialysate. The filter comprises a semipermeable membrane, which separates, in use, the dialysate from the blood fluid and permits an exchange of ions between the dialysate and the blood fluid and the transfer of a proportion of the blood fluid through the membrane. The machine further comprises an ultrafiltration pump for expelling a defined quantity of the patient's blood fluid from the dialysate circuit and through the membrane to achieve the aforesaid weight loss. Therefore there is a biunique correspondence between the weight loss and the quantity of blood fluid expelled during the whole treatment and, similarly, between the weight loss in unit time, also

called the rate of weight loss, and the delivery of the ultrafiltration pump. However, this correspondence is not valid in the case where the extracorporeal circuit is provided with an infusion bag that releases a flow of infusion fluid  
5 into the blood circuit. In this case the weight loss in unit time will be equal to the difference between the ultrafiltration flow rate and the infusion flow rate.

The extent of ion exchange is a function of the concentration of salts in the blood fluid and of the natraemia  
10 of the patient's blood fluid. In other words, the quantity of salts transferred to the patient is determined by setting the concentration of ions of the dialysate and depends on the ion concentration and on the conditions of the blood fluid. The concentration of the dialysate is measured by determining the  
15 conductivity of the dialysate and is monitored during the dialysis treatment.

In less recent dialysis machines, the values of the weight loss in unit time and of the conductivity of the dialysate were kept constant throughout the treatment and were  
20 kept relatively low owing to the fact that the patient was unable to tolerate high values, and in consequence the dialysis treatments were extremely long.

The newer dialysis machines are provided with devices for setting up the treatment, in which the values of the weight  
25 loss in unit time and of the concentration of salts in the dialysate are set in such a way that they vary as a function of time. This innovation in the field of dialysis machines occurred as a result of research in which it was found that a high weight loss in unit time can be tolerated well by an  
30 average patient in the initial stage of treatment, whereas the critical stage with regard to the weight loss in unit time is the final stage of treatment, during which the patient has already lost a large part of the weight, in the form of blood fluid, and is able to tolerate a weight loss in unit time that  
35 is relatively low compared with the initial weight loss in unit time. Furthermore, research has also shown that the patient's receptiveness to the administration of salts in the form of ions is greater in the final stage of treatment

compared with the patient's receptiveness in the initial stage of the treatment. Thus, the data setting devices of the newest machines have adapted to the innovations introduced by medical research and make it possible to define both the function of the weight loss in unit time as a function of time, and the function of the conductivity of the solution of dialysate as a function of time.

Existing devices for setting up a dialysis treatment are based on various methods, some of which envisage the introduction of data on weight loss in unit time for a series of successive intervals of time of the treatment, so that a histogram is substantially defined. In the same way, conductivity data are introduced for a series of time intervals so as to define a histogram. Determination of a histogram makes it possible to define the parameters of the dialysis treatment with increasing precision as the time intervals become shorter, so that the dialysis treatment can be tailored very accurately to the requirements of a given patient. However, these methods require the input of a value for each bar of the histogram, and for this reason it takes a relatively long time to set up the dialysis treatment.

Other less refined methods envisage the setting of only the initial values and final values of weight loss in unit time and of the conductivity of the dialysate solution and the duration of the dialysis treatment and constantly varying the weight loss in unit time and the conductivity between the initial value and the final value. The setting-up time is much shorter for these methods, but they do not permit the setting up of optimum treatments for each patient.

The aim of the present invention is to provide a method of setting up a dialysis treatment in a dialysis machine that does not have the disadvantages of the prior art and, in particular, is accurate, increases the efficiency of the treatment and at the same time can be implemented easily and quickly.

According to the present invention, a method is provided for setting up a dialysis treatment in a dialysis machine provided with a device for setting up the dialysis treatment

comprising a microprocessor, a data input and a screen, the method comprising the steps of:

- supplying a group of functions of a quantity that is characteristic of the dialysis treatment as a function of time and of a variable parameter correlated with intermediate values of each function in the group;
- selecting a subset of the group of functions imposing boundary conditions that are characteristic of a particular therapy;
- assigning values to the parameter and displaying the curves corresponding to the functions of the subset and to the respective values assigned to the parameter; and
- selecting one of the functions of the subset on the basis of the images of the curves.

The present invention will now be described with reference to the accompanying drawings, which illustrate one non-limitative embodiment thereof, in which:

Fig. 1 is a schematic view of a dialysis machine constructed according to the present invention;

Figs. 2 to 7 are images displayed by a screen of the dialysis machine of Fig. 1 during setting up of a dialysis treatment; and

Fig. 8 is a block diagram, showing the operating modes of the machine of Fig. 1 in the stage of setting up of a dialysis treatment.

Referring to Fig. 1, 1 indicates the whole dialysis machine for providing dialysis treatments for patients affected by renal insufficiency. Machine 1 comprises apparatus 2 for preparing the dialysate, a dialysate circuit 3, a blood circuit 4, a filter 5 and a device 6 for setting up the dialysis treatment. Dialysate circuit 3 transports the dialysate along a path P1 through filter 5 and is connected to apparatus 2, whereas the blood circuit 4, in use, is connected to the circulatory system of a patient and conveys the blood fluid along a path P2 through filter 5, in which the dialysate fluid and the blood fluid are separated by a semipermeable membrane 7, across which the ions of the dialysate fluid are transferred to the blood fluid, whereas the impurities

contained in the blood fluid are transferred to the dialysate. The degree of exchange depends on the ion concentration of the dialysate and on the natraemia of the patient's blood fluid. Along circuit 3, downstream from filter 5, there is a branch 8  
 5 for extraction of blood fluid and an ultrafiltration pump 9 for extracting a flow rate  $Q$  of blood fluid, which passes through filter 5. In practice, ultrafiltration pump 9 provides extraction of the part of the blood fluid that crosses the semipermeable membrane 7, and in this way produces the  
 10 patient's weight loss. Apparatus 2 provides supply of the concentration of salts in the form of ions to the dialysate, whereas a sensor 10 mounted on dialysate circuit 3 detects the electrical conductivity  $C$  of the dialysate, the electrical conductivity  $C$  being correlated to the concentration of ions  
 15 in the dialysate. Apparatus 2 and ultrafiltration pump 9 are controlled by a control unit (not shown), which determines the variation of the concentration of salts and of the delivery  $Q$  of the ultrafiltration pump 9.

Device 6 comprises a microprocessor 11, a keyboard 12 and  
 20 a screen 13, which is interactive, of the "touch screen" type, and is subdivided into a zone 14, in which there are touch keys 15 for navigating and for selecting the pages of an electronic notebook, a zone 16, with touch keys 17 for controlling apparatus 2, and a zone 18 for displaying the  
 25 values for setting up the dialysis treatment and the characteristic curves of the dialysis treatment. Keyboard 12 includes hard keys 19, which include a key 19 for going into a SET MODE for setting up the dialysis treatment, a key 19 "+/-" for changing the values of the data for setting up the  
 30 dialysis treatment, and a key 19 for confirming the data.

On selecting key 19 for access to the SET MODE, keys 15 appear, indicating PROFILING, "WL", i.e. the option for setting the weight loss, and "C", i.e. setting of conductivity. Two keys 17 permit selection of the modes "PC"  
 35 (PROGRESSIVE CURVE) and "STEP" (histogram), which permit access respectively to the mode for selection of a curve of variation of the rate of weight loss as a function of time without discontinuities in the first derivative and to a mode

functions  $U(t, P)$  with a course with convexity downwards  
corresponding to the family of hyperbolas CC

$$U = \frac{D}{E + F \cdot t + t^2}$$

The progressive curve AA, BB, CC that is to be  
 5 preselected corresponds to a function  $U(t)$  of the group stated  
 above and depends on the value assigned to the discriminating  
 parameter  $P$ , which indicates the curvature of the curve  
 relating the value  $U_0$  of the initial weight loss to a value of  
 the final weight loss  $U_f$  for  $t = DT$ , and the value of the  
 10 intermediate weight loss  $U_i$  for  $t = DT/2$  according to the  
 following relation:

$$U_i = U_f + P \cdot \frac{U_0 - U_f}{100}$$

15 in which  $P$  is expressed as a percentage and  $U_f$  is an unknown  
 and is always less than  $U_0$ , representing the maximum weight  
 loss tolerated by the patient. In other words, the  
 intermediate value  $U_i$  of the weight loss is determined by  
 parameter  $P$ .

20 Although the value of  $U_f$  is unknown, the value of  $P$  equal  
 to fifty percent indicates that the curve belongs to the  
 family of straight lines AA, and microprocessor 11 calculates  
 the value of  $K$ , imposing the following condition:

$$25 \quad TWL = \int_0^{DT} (K \cdot t + U_0) \cdot dt$$

This condition means that the total weight loss is equal  
 to the area subtended by a straight line belonging to the  
 family of straight lines AA for determining coefficient  $K$ .  
 30 Once the value of coefficient  $K$  is known, microprocessor 11  
 calculates the values of the flow  $U$  as a function of  $t$  and  
 displays the straight line in the system of cartesian axes 20  
 as shown in Fig. 3.

Parameter  $P$  is variable over a range of variability  
 35 between twenty and eighty percent and for values of  $P$  greater

$$U_i = U_f + P \cdot \frac{U_o - U_f}{100} \quad \text{for } 20 < P < 50 ;$$



$$TWL = \int_0^{DT} \left( \frac{D}{E + F \cdot t + t^2} \right) \cdot dt.$$

In the five-equation system, the values DT, TWL,  $U_0$  and P are known, whereas the unknowns are  $U_f$ ,  $U_i$ , D, E and F, which  
 5 vary with variation of coefficient P.

In practice, once we have predefined the group of functions  $U(t; P)$ :

$$U = K \cdot t + U_0; \quad U = A \cdot t^2 + B \cdot t + U_0; \quad U = \frac{D}{E + F \cdot t + t^2}$$

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the imposing of boundary conditions TWL,  $U_0$ , and DT selects a subset of the group of functions  $U(t, P)$  whereas assignment of a defined value to parameter P isolates a single function  $U(t)$  from the subset, so that the systems of equations become  
 15 defined.

From the operational standpoint, once the values TWL,  $U_0$  and DT have been assigned, the operator varies parameter P by touching the box/touch key 25 and key 19 "+/-" and microprocessor 11 displays, on screen 13, the curve  
 20 corresponding to the value assigned to parameter P and displayed in the respective box/key 25. Referring to Fig. 3, each curve displayed satisfies the values TWL,  $U_0$ , and DT established on the basis of the doctor's prescription, therefore from the quantitative standpoint the therapeutic  
 25 values are satisfied. The operator can select the qualitative course of administration for each patient by visually selecting the curve that belongs to one of the families AA, BB, CC and is best suited to the characteristics of the given patient by varying parameter P. Together with the system of  
 30 cartesian axes 20, a bar 26 is displayed, which is parallel to the ordinate, is positioned to correspond to the value  $DT/2$ , and intercepts the curve at point  $U_i$ .

The course of the concentration  $C(t)$  of the dialysate as a function of time is determined similarly. In this case,  
 35 screen 13 supplies the image of Fig. 4 which shows a cartesian system 27, which has an abscissa showing the scale for time t

and an ordinate showing the scale for conductivity C expressed in mS/cm (millisiemens per centimetre), a box/touch key 28 for input of the initial and maximum conductivity  $C_0$ , a box/touch key 29 for input of the final conductivity  $C_f$ , a box 30 for displaying the progressive curve mode, a box/touch key 31 for inputting the dialysis time DT and a box/touch key 32 for inputting parameter P.

With variation of parameter P, the progressive curve belongs to a family of straight lines A1 for P equal to fifty percent, to a family of parabolas B1 with convexity upwards for P for a value greater than fifty percent, and to a family of hyperbolas C1 for a value of P less than fifty percent.

Functions C(t) with a straight-line course corresponding to the family of straight lines A1 for P equal to 50% are as follows:

$$C = K \cdot t + C_0;$$

functions C(t) corresponding to the family of curves B1 are as follows:

$$C = A \cdot t^2 + B \cdot t + C_0;$$

functions C(t) corresponding to the family of curves C1 are as follows:

$$C = \frac{D}{E + F \cdot t + t^2}.$$

In this case there is a change in boundary conditions for determining the unknowns. With regard to the straight line it is stipulated that

$$C_f = KDT + C_0 \text{ for } t = DT;$$

in which the unknown is K, whereas  $C_f$ , DT and  $C_0$  are known.

For a value of P greater than fifty percent the curve belongs to the family of parabolas B1 and the following conditions are imposed:

$$C_i = A \cdot \left(\frac{DT}{2}\right)^2 + B \cdot \frac{DT}{2} + C_0 \text{ for } t = DT/2;$$

$$C_f = A \cdot DT^2 + B \cdot DT + C_0 \text{ for } t = DT;$$

$$C_i = U_f + P \cdot \frac{C_0 - C_f}{100} \text{ for } 50 < P < 80$$

In the three-equation system, A, B and  $C_i$  are unknowns and  
5  $C_0$ ,  $C_f$ , DT and P are known and are entered by the operator.

For a value of P less than fifty percent the curve belongs to the family C1 and the following conditions are imposed:

$$10 \quad C_0 = D/E \text{ per } t = 0;$$

$$C_i = \frac{D}{E + F \cdot DT/2 + (DT/2)^2} \text{ for } t = DT/2;$$

$$15 \quad C_f = \frac{D}{E + F \cdot DT + DT^2} \text{ for } t = DT;$$

$$C_i = C_f + P \cdot \frac{C_0 - C_f}{100} \text{ for } 20 < P < 50 .$$

In the four-equation system, D, E, F and  $C_i$  are unknowns and  $C_0$ ,  $C_f$ , DT and P are known and are entered by the operator.

20 In a similar manner to the preceding case, for each parameter P an image is supplied for the respective curve belonging to one of the families A1, B1 and C1 as illustrated in Fig. 5. All the curves that are displayed satisfy the conditions imposed by the operator, who can select the curve  
25 visually that is the most suitable for the patient undergoing the dialysis treatment.

According to the variant in Figs. 6 and 7, the submenu activated by selecting "SET MODE" offers the options "WL" and "CS", which replaces the "C" mode and provides for stipulating  
30 the total quantity of salts that must be transferred to the patient. Selection of option "CS" determines display of the image of Fig. 6, which shows a cartesian system 34 that has an abscissa for plotting the time t, and an ordinate for plotting the electrical conductivity C, a box/touch key 35 for input of

data relating to the quantity of salts CS to be transferred to the patient, a box/touch key 36 for entering the dialysis time DT, a box 37 for displaying the progressive curve mode, a box/touch key 38 for entering the initial and maximum  
 5 conductivity  $C_0$ , box/touch key 39 for entering discriminating parameter P and a box/touch key 40 for input of a function FF.

Function FF is an absorption function based on algorithms of a known type that make reference to the characteristics of filter 5 and to the equivalent conductivity that is determined  
 10 on the basis of the general characteristics of a given patient, for whom the dialysis treatment is required.

With variation of parameter P, the curves are for example represented by the curves A1, B1 and C1.

In the case when P is equal to fifty percent, the curve  
 15 belongs to family A1 and the conditions imposed are as follows:

$$C_i = C_f + \frac{C_0 - C_f}{2};$$

$$20 \quad C_i = \frac{K \cdot DT}{2} + C_0;$$

$$CS = \int_0^{DT} FF(t) \cdot (K \cdot t + C_0) dt.$$

In the case when P is between fifty and eighty percent,  
 25 the curve belongs to the family of curve B1 and the conditions imposed are as follows:

$$C_i = A \cdot \left( \frac{DT}{2} \right)^2 + B \cdot \frac{DT}{2} + C_0 \text{ for } t = DT/2;$$

$$30 \quad C_f = A \cdot DT^2 + B \cdot DT + C_0 \text{ for } t = DT;$$

$$C_i = U_f + P \cdot \frac{C_0 - C_f}{100} \text{ for } 50 < P < 80$$

$$CS = \int_0^{DT} FF(t) \cdot (A \cdot t^2 + B \cdot t + C) \cdot dt$$

In the four-equation system, the unknowns are  $C_f$ ,  $C_i$ ,  $A$  and  $B$ , whereas  $P$ ,  $DT$ ,  $CS$ ,  $C_0$  and the function  $FF(t)$  are known.

5 In the case when  $P$  is between twenty percent and fifty percent, the curve belongs to the family of curves  $C_1$  and the boundary conditions are as follows:

$$C_0 = D/E \text{ per } t = 0;$$

10

$$C_i = \frac{D}{E + F \cdot DT/2 + (DT/2)^2} \text{ for } t = DT/2;$$

$$C_f = \frac{D}{E + F \cdot DT + DT^2} \text{ for } t = DT;$$

15

$$C_i = C_f + P \cdot \frac{C_0 - C_f}{100} \text{ for } 20 < P < 50 ;$$

$$CS = \int_0^{DT} FF(t) \cdot \left( \frac{D}{E + F \cdot t + t^2} \right) \cdot dt .$$

20 In the five-equation system the unknowns are  $C_f$ ,  $C_i$ ,  $D$ ,  $E$  and  $F$ , whereas  $CS$ ,  $P$ ,  $C_0$ ,  $DT$  and  $FF(t)$  are known.

Once the coefficients of the curve corresponding to the assigned value of  $P$  are known, microprocessor 11 displays the curve in Fig. 7, and the operator visually monitors the course of the curve with variation of time. On the basis of visual  
25 monitoring and the patient's characteristics, the operator alters the value of  $P$  if he considers that the course must be corrected, or confirms with hard key 19 of keyboard 12 if the course of the curve is appropriate to the characteristics of a given patient.

30 Also when determining the conductivity function  $C(t)$ , the curve is selected from among a group of functions  $C(t, P)$  parametrized with parameter  $P$  and a subset of functions  $C(t, P)$

is selected, imposing the boundary conditions DT, C<sub>0</sub> and C<sub>f</sub> or CS, FF(t), DT and C<sub>0</sub> and, finally, function C(t) is preselected by selecting a defined value of parameter P.

According to another variant, having determined the function U(t) and the respective curve, i.e. the variation of weight loss as a function of time t, the screen shows a touch key 17, which offers the option "MIRRORING" for determining function C(t) and the respective curve, i.e. the variation of the conductivity C as a function of time using only the data that were entered in connection with determination of curve U(t) and two constants M and N, which have previously been entered in the memory of microprocessor 11.

The option "MIRRORING" imposes the condition that the difference between initial flow U<sub>0</sub> and final flow U<sub>f</sub> expressed in litres/hour is equal to the difference between the initial conductivity C<sub>0</sub> and the final conductivity C<sub>f</sub> expressed in mS/cm (millisiemens per centimetre) for a known proportionality factor N. This relation is expressed by equation NN:

$$[U_0 - U_f]_{l/h} = N \cdot [C_0 - C_f]_{mS/cm}.$$

The option "MIRRORING" also stipulates that the initial flow U expressed in litres/hour is equal to the initial conductivity C expressed in mS/cm for a constant M. This relation is expressed by equation MM:

$$[U_0]_{l/h} = M \cdot [C_0]_{mS/cm}.$$

The option "MIRRORING" further envisages that curve C(t) should have the same qualitative course as curve U(t), i.e. that parameter P should be the same for both curves. Obviously the treatment time DT is the same. Therefore, the values of C<sub>0</sub> and C<sub>f</sub> can be obtained from equations NN and MM, whereas DT and P are known, and accordingly it is possible to impose the conditions for determining the coefficients of the curve in the manner described previously.

In practice, three different means have been described for determining the course of the function  $C(t)$  and of the respective curve. These different means can coexist in the device 6 for setting up the dialysis treatment.

5 Referring to Fig. 8, the operations of setting up the dialysis treatment are shown schematically as a block diagram. Block 100 indicates selection of key 19 "SET MODE", which gives access to the options "WL" (block 110), option "C" (CONDUCTIVITY) and CS (CONDUCTIVITY/SALT) grouped in block 10  
10 220. Selection of option WL gives access to selection between the option "PROGRESSIVE CURVE" (block 120) and the option "STEP CURVE" (block 115). Selection of the option "PROGRESSIVE CURVE" gives access to block 130 for input of data  $U_0$ , DT and TWL and to block 140 for input/change of P. Assignment of a  
15 value of P determines that verification (block 150) of whether P is greater than, equal to or less than 50 is executed. For P equal to 50, microprocessor 11 calculates coefficient K of one of the families of straight lines AA (block 160). For  $P > 50$ , microprocessor 11 calculates the coefficients A and B of a  
20 parabola of family BB (block 170) and for P less than 50, microprocessor 11 calculates the coefficients D, E and F of a hyperbola of family CC (block 180). Once the coefficients of the function corresponding to a given value of P and to a given curve have been calculated, microprocessor 11 displays  
25 the curve determined by the value assigned to P on screen 13 with reference to cartesian system 20. Once the curve is displayed, the operator decides (block 200) whether to modify the curve by entering a new value of P (block 140) so that microprocessor 11 repeats the operations shown schematically  
30 in the blocks from 150 to 190 for displaying the curve corresponding to the new value assigned to parameter P or for confirming the curve (block 210). Changing of parameter P is repeated until the operator considers that the curve is suitable for setting up the dialysis treatment. Confirmation  
35 (block 210) is effected by means of a confirmation key (HARD KEY) 19. Once the curve corresponding to function  $U(t)$  has been confirmed, the operator has three options for defining the course of the conductivity function  $C(t)$  with variation of

time  $t$ . Options C and CS have already been described and have been combined in block 220 as they only differ from one another in regard to the data that are entered by the operator. The option "MIRRORING" (block 330) prevents the  
5 input of the data as obtained from the data supplied for defining the curve of  $U(t)$  and from the constants  $M$  and  $N$  obtained experimentally. Selection of the option C/CS offers the options "PROGRESSIVE CURVE" and "STEP CURVE". Selection of "PROGRESSIVE CURVE" determines presentation of the input of  
10 data (block 240) which, in the case of option "C", are substantially  $C_0$  and  $C_f$ , since  $DT$  is known and, in the case of option "CS", are substantially CS,  $C_0$  and  $FF(t)$ , since  $DT$  is known. Parameter  $P$  is entered (block 250) and compared with the discriminating value 50 (block 260) for determining the  
15 coefficients of the functions corresponding to the families of curves A1, B1 and C1. The curve of function  $C(t)$  corresponding to the value of  $P$  is displayed on screen 13 (block 300) and the operator has the option of deciding (block 310) whether to change the value of  $P$  (block 250) and whether to confirm the  
20 curve displayed (block 320) by means of a hard key 19.

Selection of the option "MIRRORING" determines calculation of  $C_0$  and  $C_f$  (block 340), after which calculation of the coefficients of a function  $C(t)$  corresponding to a curve belonging to the families A1, B1 and C1, display of the  
25 curve and confirmation (blocks from 260 to 320) are effected in the same way as for option C. If the curve displayed by means of the MIRRORING operations does not satisfy the operator, the curve is altered by varying the value of  $P$  (block 250) and the microprocessor repeats the operations  
30 between blocks 260 and 310.

According to another variant, if the operator considers that some values of the curve do not satisfy the therapeutic requirements he also changes the values of the initial conductivity  $C_0$ , final conductivity  $C_f$  and quantity of salts to  
35 be transferred to the patient CS.

In other words, the "MIRRORING" operation is able to supply a curve that is acceptable in itself, or a base curve



that is close to the acceptable curve and can be altered for adapting the curve to the therapeutic requirements.

In the example described, the function  $U(t)$  of weight loss in unit time corresponds in fact to the delivery  $Q(t)$  of the ultrafiltration pump 9 and setting the weight loss means setting the operation of the ultrafiltration pump during the dialysis treatment. According to another variant that is not shown, the extracorporeal circuit is provided with an infusion bag that releases a flow  $I$  of infusion fluid into the extracorporeal circuit. In this case the ultrafiltration flow  $Q$  is equal to the sum of the weight loss  $U$  in unit time and the infusion flow.